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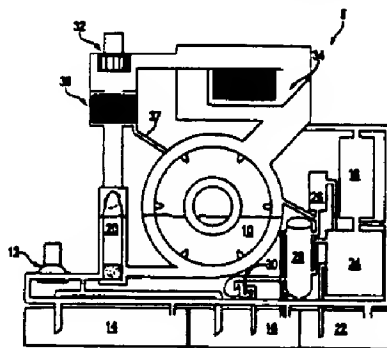
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(54) Title: SYSTEM AND METHOD FOR EXTRACTING WATER IN A DRY CLEANING PROCESS INVOLVING A SILICONE-BASED SOLVENT AND METHODS ENHANCING THE PROCESS OF CLEANING



(57) Abstract: A system and method are provided for separating water from a solvent in a dry cleaning application. According to the invention, an inlet is capable of receiving a mixture of silicone-based dry cleaning fluid and water from a condenser of a dry cleaning apparatus. A chamber is coupled to the inlet for receiving the mixture from the inlet. A porous structure is positioned in the chamber for separating the dry cleaning fluid and the water. The dry cleaning fluid passes through pores in the porous structure. An outlet is coupled to the chamber to remove the dry cleaning fluid from the chamber in the substantial absence of the water. A system for cleaning articles comprised of circulating siloxane solvent through a basket, draining the basket into tanks, centrifuging the articles and then drying the articles and recovering the siloxane solvent, and then cooling the said articles and removing said articles. In addition, the ability to remove articles after centrifuging and transfer the articles to a recovery drier allows for greater efficiency.

**SYSTEM AND METHOD FOR EXTRACTING WATER IN A DRY CLEANING  
PROCESS INVOLVING A SILICONE-BASED SOLVENT AND METHODS  
ENHANCING THE PROCESS OF CLEANING**

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**FIELD OF THE INVENTION**

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This invention is in the general field of dry cleaning of clothing, textiles, fabrics and the like, and is more particularly directed to a method and apparatus for extracting water from a dry cleaning solvent having unique density and specific weight characteristics. In addition unique changes to the methods and apparatus used to recover dry cleaning solvent and to enhance soil removal while using silicone based solvents.

**BACKGROUND OF THE INVENTION**

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Dry cleaning is a major industry throughout the world. In the United States alone, there are more than forty thousand dry cleaners (many of these have multiple locations). The dry cleaning industry is an essential industry in the present economy. Many articles of clothing (and other items) must be dry cleaned in order to remain clean by removal of body fats and oils, and presentable by preventing shrinking and discoloring.

20

The most widely used dry cleaning solvent until now has been perchloroethylene (PERC). There are numerous disadvantages to PERC including inherent toxicity and odor.

25

Another problem in this field is that different fabrics require different handling in the presently used systems in order to prevent damage to the fabrics during the dry cleaning process.

30

Prior art dry cleaning processes include the use of various solvents with appropriate machinery to accomplish the cleaning. As mentioned earlier, the solvent most widely used has been PERC. PERC has the advantage of being an excellent cleaning solvent, but the disadvantage of being a major health and environmental hazard, i.e., it has been linked to forms of cancer and it is very destructive to ground water and aquatic life. In some areas PERC is prohibited due to these disadvantages. Additionally, in the past, other solvents such as petroleum-based solvents or hydrocarbons have been tried and used. These various solvents are less aggressive than PERC,

but are still classified as volatile organic compounds (VOC's). As such, such compounds are regulated and permitted by most air districts.

5 The dry cleaning industry has long depended on petroleum-based solvents and the well-known chlorinated hydrocarbons, perchloroethylene, for use in the cleaning of fabrics and articles of clothing. Since the 1940's, PERC was praised as being a synthetic compound that is non-flammable and has great degreasing and cleaning qualities ideal for the dry cleaning industry. Beginning in the 1970's, PERC was found to cause liver cancer in animals. This was an alarming discovery, as dry cleaning waste was placed in landfills and dumpsters at that time, 10 from which it leached into soil and ground water.

Environmental Protection Agency regulations gradually were tightened, culminating in a law that took effect in 1996 that required all dry cleaners to have "dry to dry" cycles, meaning that fabrics and articles of clothing go into the machine dry and come out dry. These required "closed loop" 15 systems that can recapture almost all PERC, liquid or vapor. The process "cycle" involves placing fabrics or articles of clothing into a specially designed washing machine that can hold 15 to 150 pounds of fabrics or articles of clothing that are visible through a circular window. Prior to being placed into the machine, the fabrics or articles of clothing are checked and treated by local hand spotting for stains. If the fabric is unusual or known to be troublesome, the label is 20 checked to verify that the manufacturer has deemed the item safe for dry cleaning. If not, the stain may be permanent. If the stain is grease related, water won't help, but solvent will as it solubilizes grease. In fact, the principle reason for dry cleaning certain clothes (which should not be washed in a regular washing machine) is to remove the build up of body oils (known as fatty acids) because they too oxidize and produce rancid nasty smells.

25 The grease and fatty acids which build up in the solvent are removed by filtration and by distillation of the solvent. In other words, the dirty solvent is boiled and all vapors are condensed through a condensation coil back to a liquid. The remaining NVR (non volatile residue) is later removed and disposed of according to regulations. The liquid recovered is comprised of both 30 solvent and water and the liquid is then passed through a separator in order to separate the two non-miscible liquids. The water may originate from the natural humidity of the ambient air exposed to the textiles prior to cleaning. Another source of moisture may be materials used during pre-spotting.

Before textiles are removed from the machine, the washer becomes a dryer. Hot air is blown through the compartment but, instead of being vented outside, the air stream goes through a condenser that condenses the vapors to liquid. The water must then be separated from the solvent and the solvent returned for reuse.

If the water is not separated from the solvent, the water will carry over into an associated storage tank and due to its density will settle on the bottom of the tank. If the level of water is sufficient it will be picked up by the pump system and may be pumped onto the articles being cleaned, which would result in damaging the articles.

If the water sits on the base tank for a sufficient amount of time, bacteria will begin to grow which will result in a very bad odor that will transfer to the articles being cleaned. The hydrocarbon solvent is a feedstock for bacteria and may quickly contribute to the growth of bacteria. The silicone-based solvent is not a feedstock for bacteria but the interface level between the lighter density solvent and the more dense water causes an interface level between the water and solvent. The polar solvent soluble contaminants in this interface level may include fatty acids, food, perspiration, and general body odor. The extended settling can quickly result in the growth of bacteria and the end result of odor.

It is therefore very critical for professional dry cleaning to control the presence of water in such a way as to not damage the articles being cleaned or cause odors that would result in customer dissatisfaction.

It should be noted that many organic solvents vary in their degree of hygroscopic. Organic solvents in general, which are not water-soluble, have the ability to adsorb moisture from their environment; hence they are hygroscopic. In the case of the cyclic and linear silicone solvents, they exhibit the property of adsorbing water (their saturation points are around 200 parts per million). The rate at which they adsorb water is increased when the solvents are heated in the presence of moisture. In a dry cleaning application, where garments are immersed in the silicone solvent during the washing process and later centrifuged, any remaining solvent in the garments is removed through a tumbling and heating process. The heat causes the solvent and any moisture to evaporate. The solvent/moisture combination is transported to a cooling coil condenser at which point the resulting liquid solvent/moisture combination may be of a milky white appearance which is known as a colloidal emulsion or lyophobic colloid. This milky white

liquid is the silicone solvent coexisting with adsorbed molecular water. Over considerable time, the adsorbed water is gradually and slowly released by the solvent and the two separate given their densities and gravity. The adsorption of the water molecules on the solvent molecules can be attributed to weak van der Waals forces holding the molecules together temporarily.

5

Any two molecules attract each other and the force between them, in general terms, is called van der Waals forces. They arise from electrostatic forces between various charges in these two molecules (i.e., the constituent electrons and nuclear charges).

## SUMMARY OF THE INVENTION

It is the purpose of this invention to rapidly and effectively break-up of the forces binding  
5 molecules of the water and dry cleaning solvent, thus allowing the solvent and the water  
molecules to separate quickly. The process of stripping water from hygroscopic solvents can be  
greatly affected by the chemical nature and design of the micro-cellular stripping filter.

The process of stripping water from hygroscopic solvents can be greatly affected by the chemical  
nature and design of the micro-cellular porous structure. This is true because as the  
10 water/solvent liquid mixture is forced through the tiny orifices of the porous structure, the forces  
which cause the water molecules to adhere to the solvent molecules are reduced, thereby  
allowing the molecules to separate.

Urea-formaldehyde foam with a cell structure under 10 microns is the preferred material for  
15 construction of the porous structure. As the solvent/water liquid is forced through this rigid yet  
porous medium, the solvent and the water are immediately separated in part due to the difference  
in their densities and also due to the reduction of the adsorption forces (i.e., van der Waals  
forces). Other

factors that also play part in the separation include capillarity, surface tensions, and even the  
20 difference of attractive forces between water molecules and foam molecules verses silicone  
molecules and foam molecules. These factors along with flow rate determine the rate of  
separation.

Though rigid materials are preferred due to their ability to withstand greater pressure  
25 differences, it should be noted that certain flexible materials, such as open-cellular polyurethane  
foams, and phenyl formaldehyde polymers exhibit a similar ability to separate the solvent and  
the water and may be used to construct the porous structure. The cell size, the density of the  
foam, and the pressure at which the solvent/water liquid passes through the medium determines  
the optimum degree of water coalescing (stripping) from the solvent. As an example, 3-inch  
30 diameter rigid foam with a cell size of under 10 microns effectively allows the water stripping to  
occur successfully at a flow rate of over 3 GPM.

It should also be noted that varying materials that may be used as the porous structure will have  
differing degrees of hydrophilicity (ability to attract water). If the micro-cellular structure has a

higher degree of hydrophilicity, the effectiveness and the speed of the water stripping process is more efficient.

5 The hydrated silicone solvent, or colloids, also classified as lyophilic colloid are produced when immiscible liquids are cooled together during the condensation of vapors both during drying and during the distillation process. The proper separation of water from solvent is influenced by the proper selection of and implementation of a coalescing or stripping medium.

10 The medium selected acts primarily as a coalesce of tiny water droplets. Coalescence is an indication of destabilization of the colloidal emulsion. The most important factors in destabilizing a colloidal emulsion are: (1) upsetting double layers of electrical charges surrounding dispersed droplets in lyophobic colloids so that the "zeta potential" disappears or (2) destroying the solvated layer or film that surrounds dispersed droplets in lyophilic colloids. The droplets coagulate and the system loses its stability only when both the stabilizing double layer of charges and the solvated atmosphere surrounding the droplets are removed.

15 The "porus structure" media can also be causing soalescence by removing ions from a double layer and/or removing a solvated film. Various extended-surface media (as identified later, but not limited to) have a significant valence or other attractive forces left over at their extreme surfaces that can attract other materials, a phenomenon which is called adsorption. The adsorption of ions and surfactants by the "porus structure" media are reasonable methods by which the media can function and thereby bring about coalescence. Thus, the selection of the "porous structure" to be used as the coalesces or stripping medium is based upon its ability to in the end separate the siloxane solvent from the water.

25 The present invention includes a system and method for separating water from a silicone-based solvent in a dry cleaning application. According to the invention, an inlet is capable of receiving a mixture of silicone-based dry cleaning fluid and water from a condenser of a dry cleaning apparatus. A chamber is coupled to the inlet for receiving the mixture from the inlet. A porous structure is positioned in the chamber for separating the dry cleaning fluid and the water. The dry cleaning fluid passes through pores in the porous structure. An outlet is coupled to the chamber to remove the dry cleaning fluid from the chamber in the substantial absence of the water.

In one aspect of the present invention, the cell size of the porous structure is under 10 microns. The porous structure can be constructed of urea-formaldehyde foam. Ideally, the cell size of the urea-formaldehyde foam is under 5 microns. Alternatively, the porous structure can be constructed of a polyurethane foam, ideally with a cell size of under 5 microns but may exceed 10 microns. In another aspect of the present invention, the porous structure is hydrophilic.



Alternatively the porous structure can be constructed of a phenyl formaldehyde polymer foam, ideally with a cell size of under 10 microns.

In one aspect of the present invention the use of fractional distillation may allow for the

5 illumination of water from solvent based on density and re-circulation. Low-end boilers such as water can be distilled prior to the distillation of silicone solvent.

The ideal distillation of silicone solvent is by producing temperatures of between 235 F and 250 F with a vacuum of from 27 inches to 29 inches. By producing temperatures above the boiling  
10 point of water 212 F and creating a slight vacuum < 20 inches the process is able to vapor off the low-end boilers and urge the condensed vapors to a separate vessel. Some azeotropic will occur and thus a water sensor on this vessel will cause the free water present to leave the system. The remaining hydrated solvent will return to the still for re-distillation.

15 After low-end boilers have been distilled (based on either time or an increase in temperature) the full vacuum (27 to 29 inches) is established with the full temperature (235 F to 250 F) also established resulting in distillation of dehydrated silicone solvent. The condensed vapors are urged to a separate vessel that may have a water sensor, for safety, allowing the water if present to leave the system. The solvent is returned to the tanks on the dry cleaning machine for reuse.

20 The second source of hydrated solvent is from the drying recovery head, this solvent is normally very hydrated and is collected in a separate vessel that may contain a water sensor so as to eliminate free water. After the drying recovery cycle the collected hydrated solvent is urged to the still for distillation, thus the only solvent being re-cycled is through the high-end boiler vessel of the fractional distillation operation.

the use of silicone-based solvent allows for latitudes in temperatures that have not traditionally existed in the dry cleaning field. The importance of controlling the temperature of the liquid solvents that are used in the field of dry cleaning is critical.

5 The most prevalent solvent used as previously stated is PERC whose temperature is ideally maintained at a range of 78 to 82 degrees Fahrenheit. This is also a common range for all other solvents currently being used in the field of dry cleaning. If the temperature should increase, the result is a much more aggressive solvent resulting in damage to textiles being processed. The increase in the KB (kari butyl) value most often results in causing dyes to be solubilize from  
10 articles being cleaned, resulting in the transfer of these dyes to other articles being cleaned. The concern for controlling temperature has caused manufactures of dry cleaning machines to install water cooling coils placed in the base tanks, and in-line water cooling jackets on the plumbing lines for heat transfer.

15 By increasing the temperature of the silicone-based solvent of the present invention to a range of 90 to 130 degrees Fahrenheit, an aggressiveness in cleaning is afforded, without the result of pulling or stripping dyes. This may be best accomplished by circulating water in a closed loop fashion between a hot water tank and through a circulating pump and through the coils (previously used for cooling) and back to the hot water tank. The circulating pump is controlled  
20 by a temperature probe that can be placed in the solvent. The result is precisely controlled solvent temperature which influences the aggressiveness of the solvent without causing damage to the articles being cleaned. This is optional and is not necessary to achieve good cleaning.

25 While various embodiments have been described above, it should be understood that they have been presented by way of example only, and not limitation. Thus, the breadth and scope of a preferred embodiment should not be limited by any of the above-described exemplary embodiments, but should be defined only in accordance with the following claims and their equivalents.

## DESCRIPTION OF THE DRAWINGS

The aforementioned advantages of the present invention, as well as additional objects and advantages thereof, will be more fully understood hereinafter as a result of a detailed description of a preferred embodiment when taken in conjunction with the following drawing in which:

Figure 1 is a schematic that represents a dry cleaning machine that is used with solvent that has a boiling point that if distilled requires vacuum distillation;

Figure 2 is a flow diagram indicating the flow of liquid in a dry cleaning apparatus as described in Figure 1;

Figure 3 is a flow diagram indicating the flow of vapor in a dry cleaning apparatus as described in Figure 1;

Figure 4 is a flow diagram indicating the functional steps of the method of separating water from the solvent using a separate apparatus; and

Figure 5 is a flow diagram indicating the functional steps of separating water from solvent using an apparatus as a part (OEM) of the dry cleaning machine;

Figure 6 is a flow diagram and schematic of a separator with functional steps of the separation of water from solvent.

Figure 7 is a flow diagram indicating the functional steps of condensing liquid in a transfer drier and moving the liquid to a separator.

Figure 8 is a schematic that represents a transfer drier that is used with solvent that has a boiling point that requires vacuum distillation.

**DISCLOSURE OF THE INVENTION**

The present invention includes an apparatus and method used in conjunction for the dry cleaning of fabrics, textiles, leathers and the like.

To perform the interrelated cleaning steps involving the present invention, a dry cleaning apparatus is shown schematically in Figure 1, although it is recognized that alternative cleaning configurations can be used. It should be noted that the cleaning configuration of Figure 1 may be used for processing with a Class 3-A (solvent having a flash point between 140 F and 200 F) type solvent.

The dry cleaning of articles or other items begins by placing them in a horizontal rotating cleaning basket 10. The wash cycle is initiated with a dry cleaning fluid including an organo silicone-based siloxane solvent being pumped using a pump 12. The solvent is pumped from either a working tank 14, or a new solvent tank 16, and then to the cleaning basket 10 with the articles. The course of the pumped solvent can either be through a filter 18, or directly to the cleaning basket 10.

From the cleaning basket 10, the solvent is then circulated through the bottom trap 20 to the pump 12. After agitation for a predetermined amount of time, the solvent is drained and pumped to either of the three tanks 14, 16, and 22 shown in Figure 1. The cleaning basket 10 is then centrifuged in order to extract the remaining solvent to any of the tanks or to the still.

The types of filtration systems compatible with the particular solvent of the present invention are: a spin disc of a 20 and 60 micron type and may use diatomaceous earth being capable of optional use with the larger micron spin disc type; a tubular filtration (flex, rigid, or bump) also being capable of optional use with diatomaceous earth; a cartridge (carbon core, all carbon of the standard size, jumbo or split size); and Kleen Rite cartridge system which may result in no need for a still. Filters may also be used with a dimension between 10 to 100 microns to filter condensed vapors prior to separation.

The solvent may be filtered so as to eliminate the particulate soil that is released from the articles

being cleaned. Further, filtering of the silicone-based solvent eliminates the polymerization of the solvent even in the presence of catalysts.

5 The solvent being used for cleaning may be distilled at a rate of 10 to 20 gallons per hundred pounds cleaned, unless the aforementioned Kleen Rite cartridge system is being used. To accomplish this, a still 24 may be used to receive solvent from the filter 18, or from the dirty tank 22, or the wheel 10. The solvent in the dirty tank 22 can be introduced to the still through suction since the still is under a vacuum that maybe controlled by a float ball valve (not shown).

10 Any recovered or condensed vapors originating from the still may be condensed by water-cooled coils of a still vapor condenser 26. Thereafter, gravity urges the condensed solvent into a primary separator 28 or holding vessel. The rate of flow, depending on the still, may range between .75 and 2.50 GPM, and the separator is engineered accordingly. Vacuum may be created by a liquid-head pump 30 or an evacuation process created by a venturi.

15 During the drying process either as a part of the same machine or transferred to the drier, the articles are tumbled in 10 with air being forced by a fan 32 over heating coils 34, which results in the incoming air flow to be between 120 and 180 degrees Fahrenheit. As the solvent and water remaining on the articles are heated and become vapor, the airflow exits the cleaning basket 10  
20 and passes over cooling coils of a drying vapor condenser 36 where the vapors condense back to a liquid. Gravity urges such liquid to the primary separator 28 or holding vessel via a conduit 37.

The vapor laden air that leaves the cleaning basket 10 ranges in temperature between 120 and 160 degrees Fahrenheit. This temperature is important in that it can also be an advantage to  
25 regulate the temperature at or below 140 degrees such that the temperature is 30 degrees Fahrenheit below the flash point of the aforementioned solvent. In one embodiment, the rate of flow of the condensed liquid may be limited to 0.75 GPM, and the separator may thus be engineered for the combined flow rate of condensed liquid from the still and drying vapor  
condensers 26 and 36.

30 Figure 2, 3 & 4 illustrates an order in which the various components of the present invention may be employed for clarification purposes. Having followed the foregoing process of dry cleaning, there are no less than one but as many as two or more sources of solvent to the

separator. The ability to return re-condensed solvent to the dry cleaning system is dependent on the separator and its efficiency.

To afford such efficiency, a method of water and solvent separation is provided, as shown in Figure 4, 5, & 6. As shown, a mixture of the silicone-based dry cleaning fluid and any water from the articles is received from one or both sources of condensed solvent being; drying and or distillation of the dry cleaning process. Upon receipt, the mixture may either enter a holding vessel or be urged directly through a porous structure that separates the dry cleaning fluid and the water. Next, the dry cleaning fluid is removed in the substantial absence of water and is recycled into the dry cleaning system.

Figure 6 is a schematic of the separators of one embodiment of the present invention, which is capable of performing the method of Figure 4 & 5. As the flow of the hydrated solvent, or mixture of water and dry cleaning fluid, approaches a main chamber 48 of the separator Figure 4, 5, & 6 the mixture may be filtered 54 to prevent lint and particulate soil from entering the separator Figure 6 which may in turn restrict a coalescent filter that is downstream. To accomplish such filtering, coalescent media 54 may be draped at the initial termination of an inlet tube 52. The various media of the present invention may include nylon or any other coalescing media. The plumbing connection from the vapor condensers 26 and 36 of the dry cleaning of Figure 1 & 8 may be plumbed to terminate at inlet 52

The hydrated solvent enters the separator Figure 4, 5 & 6 where gravity feeds it down the inlet tube 52, which terminates several inches above an interface level between the water and the dry cleaning fluid. The silicone-based solvent is insoluble in water, yet water, in small cellular size does suspends itself in the hydrated solvent until they form globules. Due to the combined weight, the globules settle to the bottom of the main chamber 48.

As the overall liquid in the main chamber 48 rises, a float level switch 58 is tripped which in turn activates a pump 60. The liquid is then pumped by the pump 60 through either 1 or 2 filters 62 that are rated as high as 20 to 50 microns and as low as 5 microns for filtering Figure 4, 5 & 6.

The hydrated solvent is then forced or pulled through a porous structure 64 which may be positioned within the filter housing 62 or placed in-line post filter 62 and which acts as a "coalescing medium". Preferably, this structure is between 1/2 and 15 inches in length with a cross-section between 1/4 and 4 inches and has a cell size of under 20 microns. It should be noted that there can be as many as one to three or more separate structures 64 positioned in line of the filter housing 62. Some of the water globules are created as the hydrated solvent is forced through the porous structure 64 and appear on the outgoing side of the porous structure 64.

The pump 60 may be electrical or pneumatic in form. The use of any flow method such as the pump 60 or, in the alternative, a vacuum results in sufficient separation. The flow methodology chosen should affect a flow of 0.5 to 3.5 GPM. If the inflow of hydrated solvent is greater than the porous structure 64 will allow, the re-positioning of the float level switch 58, which activates the flow controller, can be lowered to allow for a larger buffer for the hydrated solvent. The flow rate can be modified by raising or lowering the air pressure or using a throttling valve.

The hydrated solvent is moved from the primary vessel 48 through the suction line 59, through the filter or filters 62. The hydrated solvent is exposed to the stripping media 64 and then out into the final vessel 68 having passed through a diffuser 65 and into the dry cleaning machines clear tank 16, Figure 1.

Located on the final vessel are three outlets. The highest is a safety overflow 70 which carries the solvent back to the primary vessel 48. The middle height line 66 carries the solvent to the clear tank 16 and the lower line 67 carries the possibly hydrated solvent to the primary vessel 48 and creates a closed-loop process to protect the clear tank 16 from hydrated solvent.

When this process is applied to an OEM (original equipment manufacture) system the principals are the same but the vessels may change. As demonstrated in Figure 6 the source of the condensed liquid 26 and 36 are the same with the hydrated solvent routed to the first vessel 48 which if equipped with a water sensor 71 will actuate a valve so as to drain the water off and close again once the water has been removed. The hydrated solvent will be circulated either by an add on pump 60 or using an exiting dousing pump 60 that will circulate the hydrated solvent from the vessel 48 through a filter (less than 10 micron) 62 and then through the stripping medium 64 which will cause the water molecules to form globular size water structures which

are then sensed by the water sensor 71 and thus drained from the vessel 48. This leaves a dehydrated solvent that can safely be recycled to the clear tank 16 Figure 1.

5 The water that is collected at the bottom of the main chamber 48 & 68 is evacuated manually or by a water float switch (not shown) which mechanically opens a hinged valve. There is also an option of using two conductivity points, or probes (not shown), that make contact as the water rises in order to complete a circuit to signal either a pneumatic or electric valve which may discharge the water that is in the main chamber 48 & 68. There may also be a manual drain at the bottom of the main chamber 48 & 68 for manual periodic maintenance.






10 The composition of the main chamber 48 & 68 can be stainless steel, or polyethylene. Constructing with the use of carbon steel is discouraged since oxidation and rusting can quickly occur.



## CLAIMS

What is claimed is:

1. A system capable of separating water from a silicone-based solvent in a dry cleaning application, comprising:
  - (a) an inlet capable of receiving a mixture of silicone-based dry cleaning fluid and water from a condenser of a dry cleaning apparatus;
  - (b) a chamber coupled to the inlet for receiving the mixture from the inlet;
  - (c) a porous structure positioned in the chamber for separating the dry cleaning fluid and the water, wherein the dry cleaning fluid passes through pores in the porous structure; and
  - (d) an outlet coupled to the chamber to remove the dry cleaning fluid from the chamber in the substantial absence of the water.
2. The system recited in claim 1, wherein the cell size of the porous structure is under 10 microns.
3. The system recited in claim 1, wherein the cell size of the porous structure is under 5 microns.
4. The system recited in claim 1, wherein the porous structure comprises urea-formaldehyde foam.
5. The system recited in claim 4, wherein the cell size of the urea-formaldehyde foam is under 5 microns.
6. The system recited in claim 1, wherein the porous structure comprises a polyurethane foam.
7. The system recited in claim 6, wherein the cell size of the polyurethane foam is under 5 microns.
8. The system recited in claim 1, wherein the porous structure comprises a phenoyl formaldehyde polymer foam.

9. The system <sup>recited</sup> ~~recited~~ in claim 8, wherein the cell size of the phenoyl formaldehyde foam is under 10 microns
10. The system <sup>recited</sup> ~~recited~~ in claim 1, wherein the porous structure is hydrophilic.
- 5 11. The system <sup>recited</sup> ~~recited~~ in claim 1, further comprising a flow controller for urging the mixture through the chamber.
12. The system <sup>recited</sup> ~~recited~~ in claim 11, wherein the flow controller is a vacuum.
13. The system <sup>recited</sup> ~~recited~~ in claim 11, wherein the flow controller is a pump.
14.  The system <sup>recited</sup> ~~recited~~ in claim 13, wherein the pump is an electrical pump.
- 10 15.  The system <sup>recited</sup> ~~recited~~ in claim 1, and further comprising a filter coupled to the inlet having perforations with a dimension between 10 to 100 microns.
16.  The system <sup>recited</sup> ~~recited~~ in claim 1, and further comprising a second coalescent media coupled to the inlet for further coalescing.
- 15 17.  The system <sup>recited</sup> ~~recited~~ in claim 1, wherein gravity urges the water from the chamber through a drain tube.
18.  The system <sup>recited</sup> ~~recited~~ in claim 1, wherein the water is drained from the chamber through a valve that is activated by conductivity created by two probes that complete a circuit upon the presence of water.
- 20 19. A method of separating water from a silicone-based solvent in a dry cleaning application, comprising the steps of:
- (a) receiving a mixture of silicone-based dry cleaning fluid and water;
  - (b) urging the mixture through a porous structure for separating the dry cleaning fluid and the water; and

(c) removing the dry cleaning fluid in the substantial absence of the water.

20. The system recited in claim 19, wherein the cell size of the porous structure is under 10 microns.

5 21. The system recited in claim 19, wherein the cell size of the porous structure is under 5 microns.

22. The system recited in claim 19, wherein the porous structure is hydrophilic.

23. The system recited in claim 19, wherein the porous structure comprises urea-formaldehyde foam.

10 24. The system recited in claim 23, wherein the cell size of the urea-formaldehyde foam is under 5 microns.

25. The system recited in claim 19, wherein the porous structure comprises a polyurethane foam.

15 26. The system recited in claim 25, wherein the cell size of the polyurethane foam is under 5 microns.

27. The system cited in claim 19, wherein the cell size of the phenoyl formaldehyde foam is under 10 microns.

20 28. The system recited in claim 19, wherein the water is drained from the chamber through a valve that is activated by conductivity created by two probes that complete a circuit upon the presence of water.

29 A system for cleaning articles comprising:

(a) a cleaning basket for receiving articles therein;

(b) one or more tanks for containing a siloxane solvent;

25 (c) a pump coupled between the tank and the cleaning basket for immersing the articles in the cleaning basket with the siloxane solvent;

- (d) a vacuum still for distilling the siloxane solvent for reuse;
- (e) a condenser coupled to at least one of the cleaning baskets and or the still for condensing and recovering vapors;
- (f) a separator coupled to the condenser for decanting any water in the siloxane solvent  
5 received from the condenser;
- (g) a fan coupled to the cleaning basket for circulating air past both the heater coils and the cooling coils and into the cleaning basket for drying and cool-down after drying;
30. The system recited in claim 29, wherein the condenser is a still vapor condenser coupled to the still for recovering condensed vapors of the siloxane solvent from the still.
- 10 31. The system recited in claim 29, wherein the condenser is a drying vapor condenser coupled to the cleaning basket for recovering condensed vapors of the siloxane solvent from the cleaning basket.
32. The system recited in claim 29, wherein the separator receives the siloxane solvent by way of gravity.
- 15 33. A method of dry cleaning articles in a closed loop or transfer system comprising the acts of:
- (a) immersing said articles to dry cleaned in a dry cleaning fluid including a cyclic siloxane composition;
- (b) agitating said articles in said siloxane composition;
- 20 (c) centrifuging said articles for a partial removal of siloxane solvent;
- (d) removing said articles from the basket and transferring them to a recovery drier;
- (e) circulating air so as to heat articles and vapor off liquids;
- (f) circulate air so as to cool articles after recovery.
- 25 34. The method recited in claim 33, wherein said removal of said siloxane composition from said articles is carried out by a closed loop method including:
- not removing articles after centrifuging;
- circulating air over heated coils;
- circulating said air through said articles.

- 35     The method recited in claim 33, wherein during said removal of said siloxane composition from said articles, said articles are subjected to a vacuum that reduces the vapor point of said siloxane composition such that said removal of said siloxane composition is quickened.
- 5     36.     The method recited in claim 33, and further comprising an injection nozzle such that prior to washing a fine mist (atomized) of water is injected into the basket for a period of less than 1 minute to humidify the articles prior to the siloxane composition being pumped into the basket for washing.
- 10     37.     The method recited in claim 36, wherein the system is comprised of a vacuum still for distilling siloxane solvent and illuminating (NVR) non volatile residue as a part of the system.
- 38     The method recited in claim 33, wherein the system is comprised of a vacuum still for distilling siloxane solvent and illuminating (NVR) non volatile residue as a part of the system.
- 15     39.     The system recited in claim 38, whereby the still operates as a fractional distillation still.
40.     The system recited in claim 39, wherein the low-end (early) boilers are urged to a separate vessel, and the high-end boilers are urged to a separate vessel.
41.     The system recited in claim 40, wherein the vessels are equipped with a water sensors capable of indicating water and releasing water from the vessel.
- 20     42.     The system recited in claim 39, wherein the low-end vessel urges the hydrated solvent to the still for re-distillation and the high-end boiler vessel urges the solvent to return to the dry cleaning tank for reuse.
- 25     43.     The methods recited in claim 33, wherein the condensed hydrated siloxane solvent recovered during the drying cycle is urged to a separate vessel which is then urged to the still for distillation.

44. The methods recited in claim 43, wherein the vessel is equipped with a water sensor capable of indicating water and releasing water from the vessel.

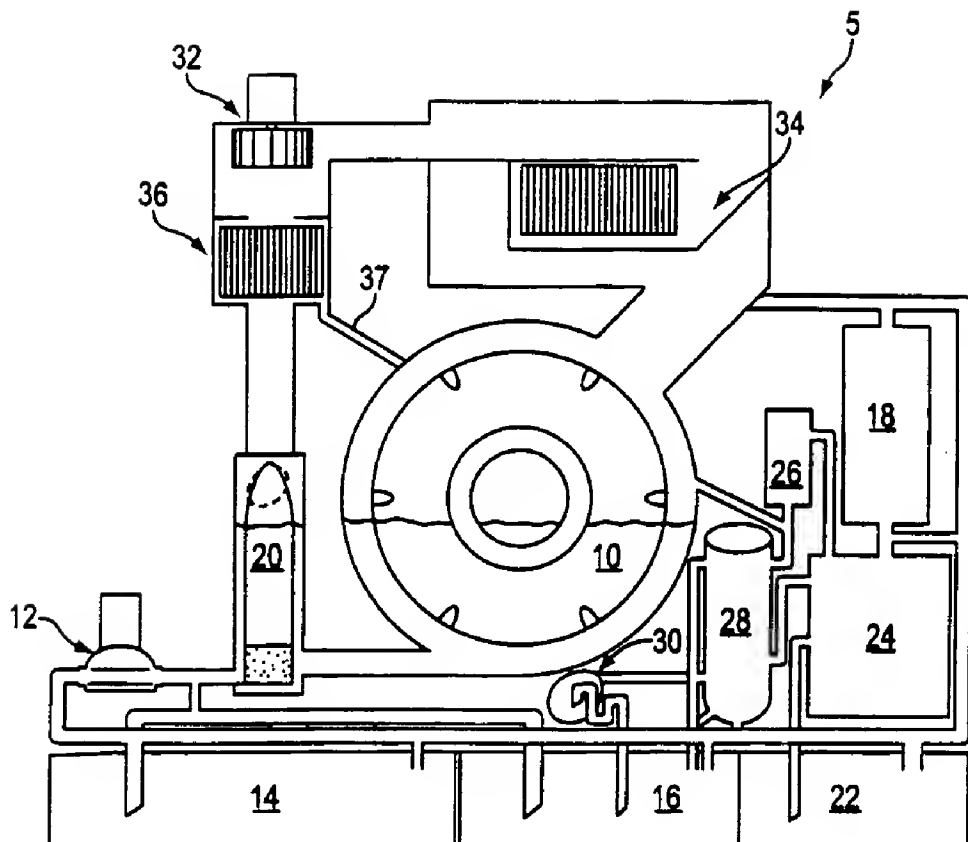


FIG. 1

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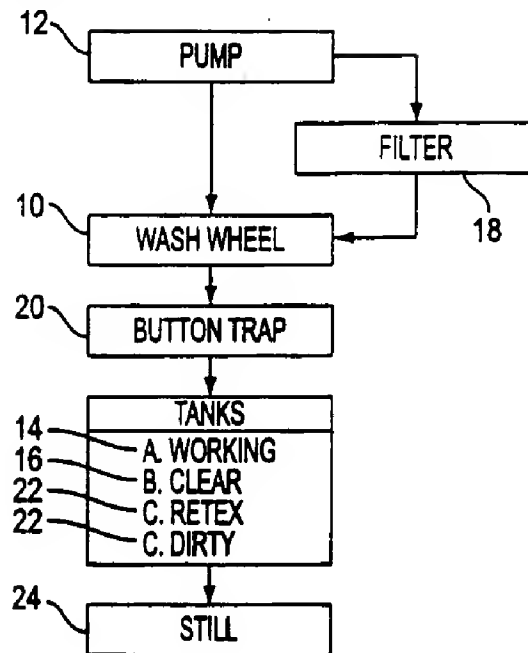
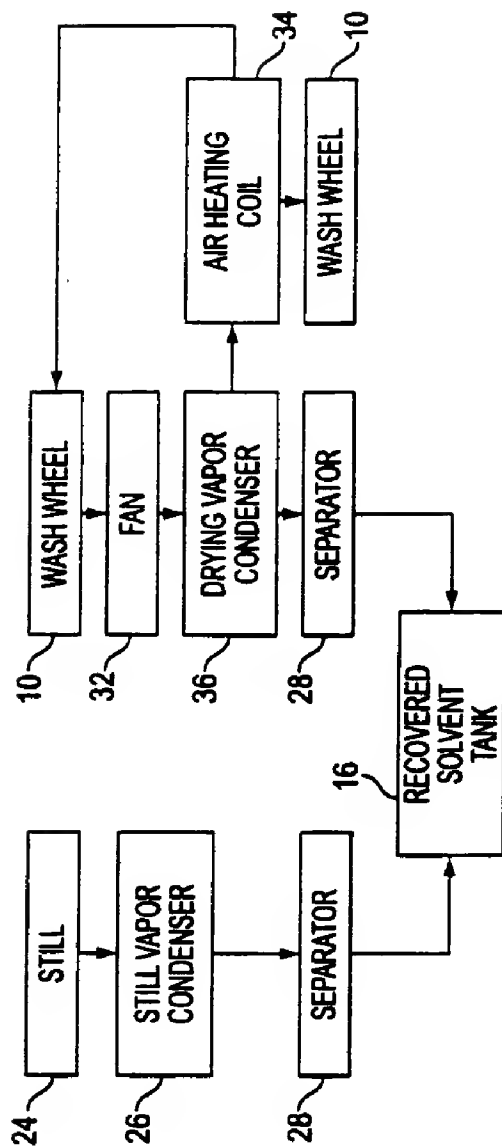
LIQUID SKEMATIC

FIG. 2



VAPOR SKEMATIC**FIG. 3**

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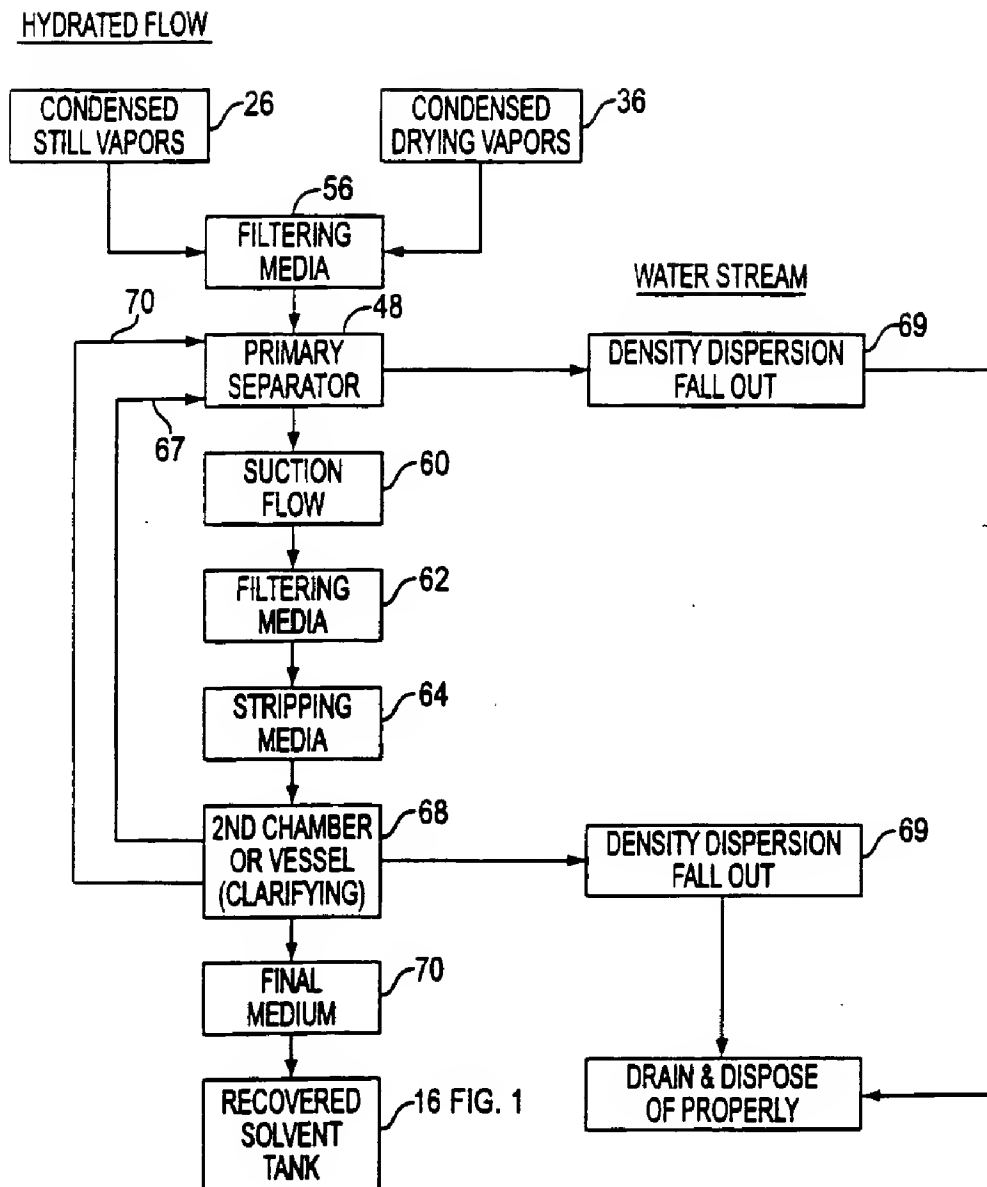


FIG. 4

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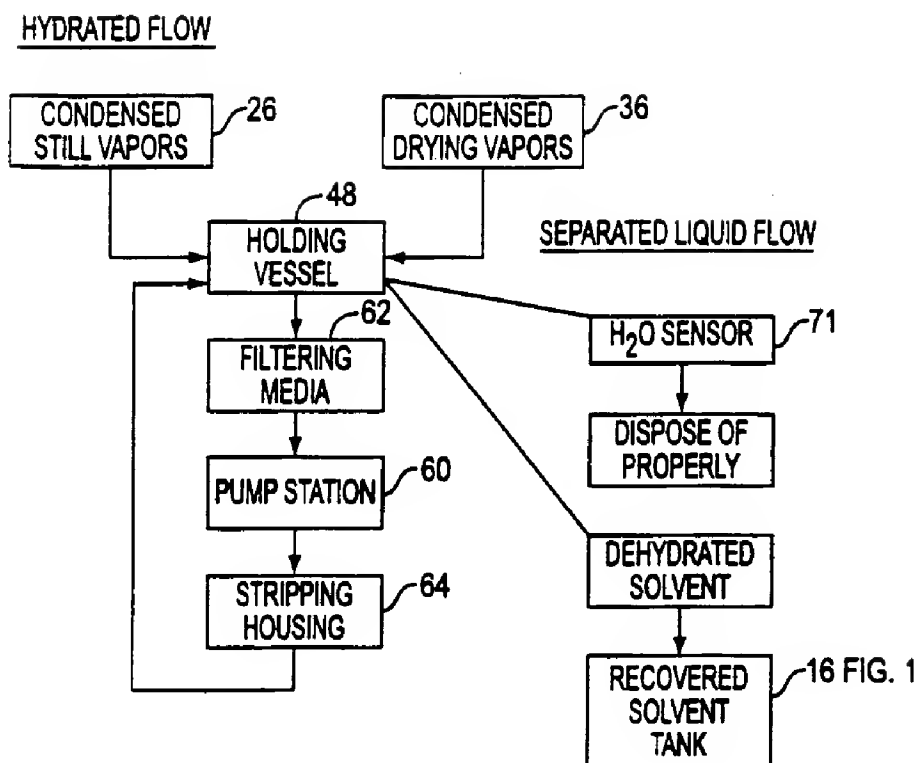


FIG. 5

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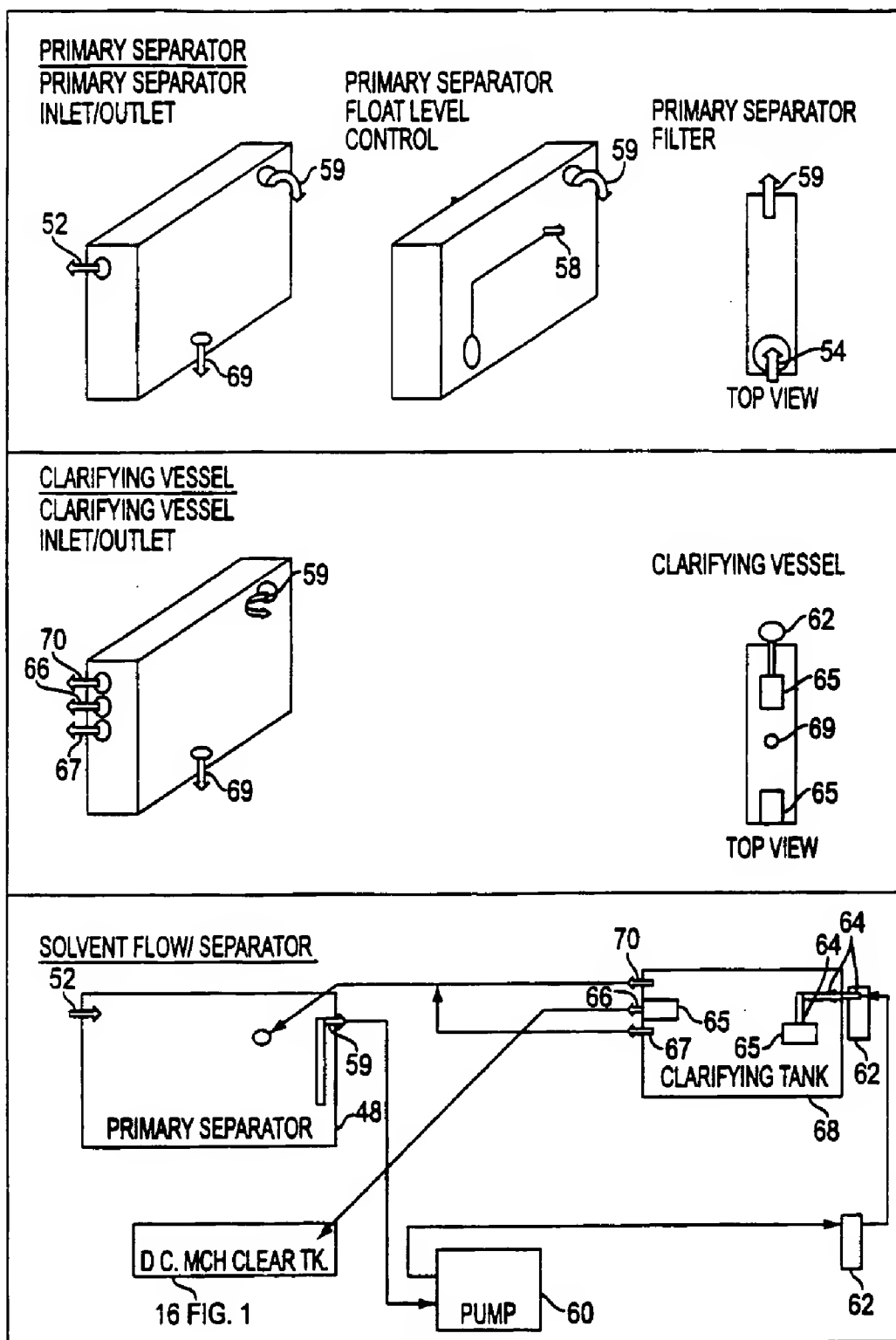


FIG. 6

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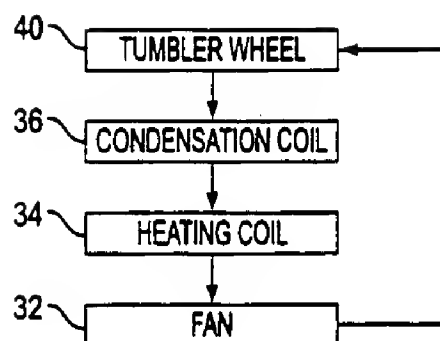
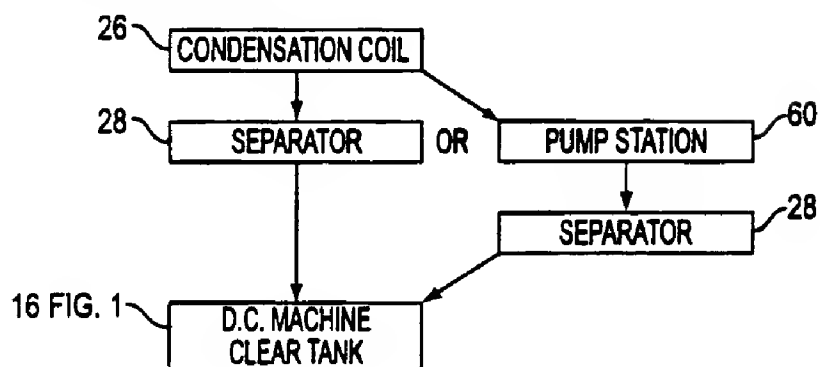
AIR FLOWRECOVERED VAPORS, LIQUID FLOW

FIG. 7

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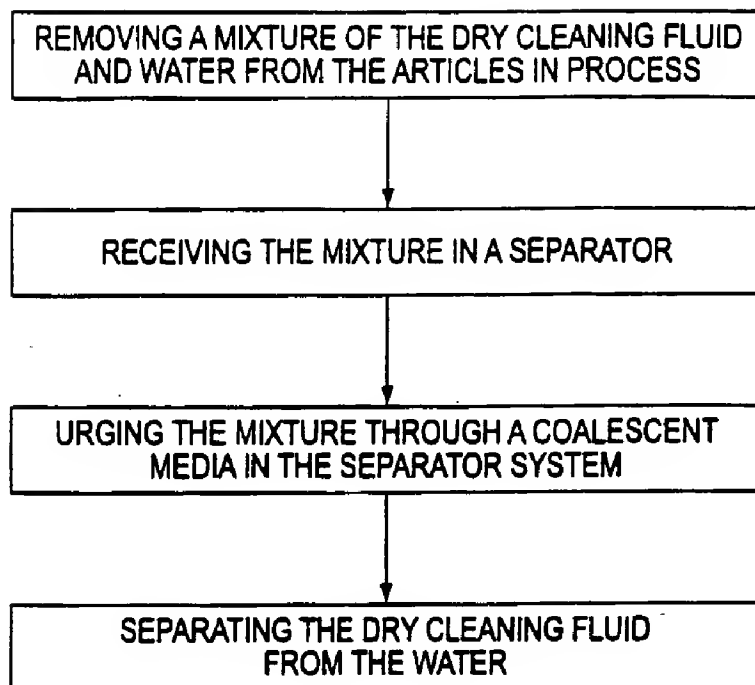


FIG. 8

## INTERNATIONAL SEARCH REPORT

Int'l Application No.

PCT/US 00/19206

A. CLASSIFICATION OF SUBJECT MATTER  
 IPC 7 D06F43/08 D06F43/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 D06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 4 708 807 A (KEMERER BEVERLY K) 24 November 1987 (1987-11-24)  column 2, line 19 - line 63 column 5, line 1 - line 13	1-3, 6, 7, 19-21, 25, 26, 29, 31, 33, 34, 36
Y	US 3 395 086 A (VICTOR IRVING) 30 July 1968 (1968-07-30)  column 2, line 24 - line 38  -/-	1-3, 6, 7, 19-21, 25, 26

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

8 November 2000

Date of mailing of the international search report

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## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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P, X	WO 00 04221 A (GREENEARTH CLEANING LLC) 27 January 2000 (2000-01-27) abstract	1, 29, 33
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information on patent family members

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